Got a Litho Question? Ask the Experts

Chris A. Mack

Q How does a reduction in excimer laser bandwidth improve resolution and CD control?

A Dispersion is defined as the variation in the index of refraction of a material with wavelength. All materials, including the optical materials used to make stepper lenses, have dispersion. For a lens, this means that the focusing ability of the lens (how it bends light) will be different for different wavelengths. In practical terms, the plane of best focus will move if the wavelength of light is changed, even slightly (lens designers call this *chromatic aberration*). Chromatic aberrations can be effectively corrected by making a lens using different types of glass, each with a different dispersion, so that the wavelength effects cancel out. I-line and g-line steppers all made use of this chromatic correction technique. Unfortunately, at a wavelength of 248 nm there is only one suitable material from which to make lenses – fused silica. All deep UV imaging systems use fused silica as the lens material. Without a second material with different dispersion characteristics, chromatic correction is not possible.

So what does this mean in terms of laser bandwidth? Without chromatic corrections, even a very small change in laser wavelength can cause a large focus shift (a focus shift of about 0.25 µm for a 1pm change in laser wavelength would not be uncommon). The laser bandwidth gives a range of wavelengths that produces a range of images spread through focus. This blurring (averaging of images through focus) gets worse as the laser bandwidth gets larger. The impact, then, on resolution and CD control comes from this blurred aerial image.

Q Why do dense line/space patterns exhibit a relatively flat response of CD through focus, while isolated lines show a significantly curved response?

A The answer to this question is contained in the concept of isofocal bias. "Isofocal" means literally "the same through focus." Thus, the isofocal CD is the critical dimension at which changing focus results in a minimum change in CD. The isofocal bias is the difference between this isofocal CD and the desired or target CD. Obviously, we would like the isofocal bias to be zero in order to print our features at the target CD with the minimum sensitivity to focus errors. The difference in curvature of focus-exposure matrix data for dense and isolated features is actually a difference in isofocal bias. Often, dense high-resolution features exhibit a fairly small isofocal bias. Thus, when printing near the correct exposure dose the CD through focus response is quite flat. Small isolated lines exhibit a large positive isofocal bias (the CD with the flattest response to focus is much larger than the target CD). Thus, when working at the dose to size a plot of CD through focus will show extreme curvature (going out of focus will make the lines smaller).

Why do isolated lines show such a large isofocal bias compared to dense features? The answer lies in the nature of partially coherent imaging, a difficult subject to grasp intuitively. Simulation is often used to understand these issues.

Do you have a lithography question?

Just e-mail lithocolumn@kla-tencor.com and have your questions answered by Chris Mack or another of our experts.

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